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(54) Abstract Title: **Drilling with concentric strings of casing**

(57) A method and apparatus for setting concentric casing strings 12, 15, 18 within a wellbore in one run-in of a casing working string. In one aspect of the invention, the apparatus comprises a drilling system 9 comprising concentric casing strings 12, 15, 18 with each casing string having a drill bit piece 13, 16, 19 disposed at the lower end thereof. The drill bit pieces of adjacent casing strings are releasably connected to one another by connectors 14, 17, each of which may be shearable by longitudinal forces of different magnitude, such as weight sheared pins, locking mechanisms, splines or a torque key system. In another aspect of the invention the concentric casing strings are releasably connected and have only a single drill bit (fig 7).

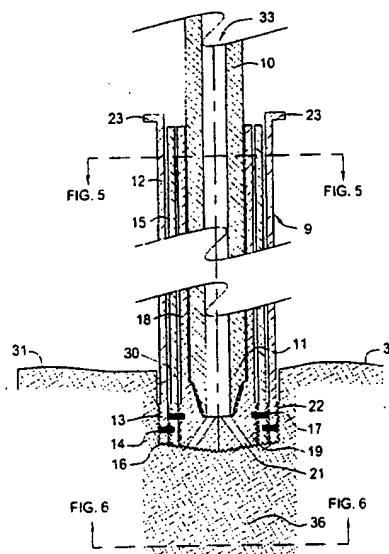
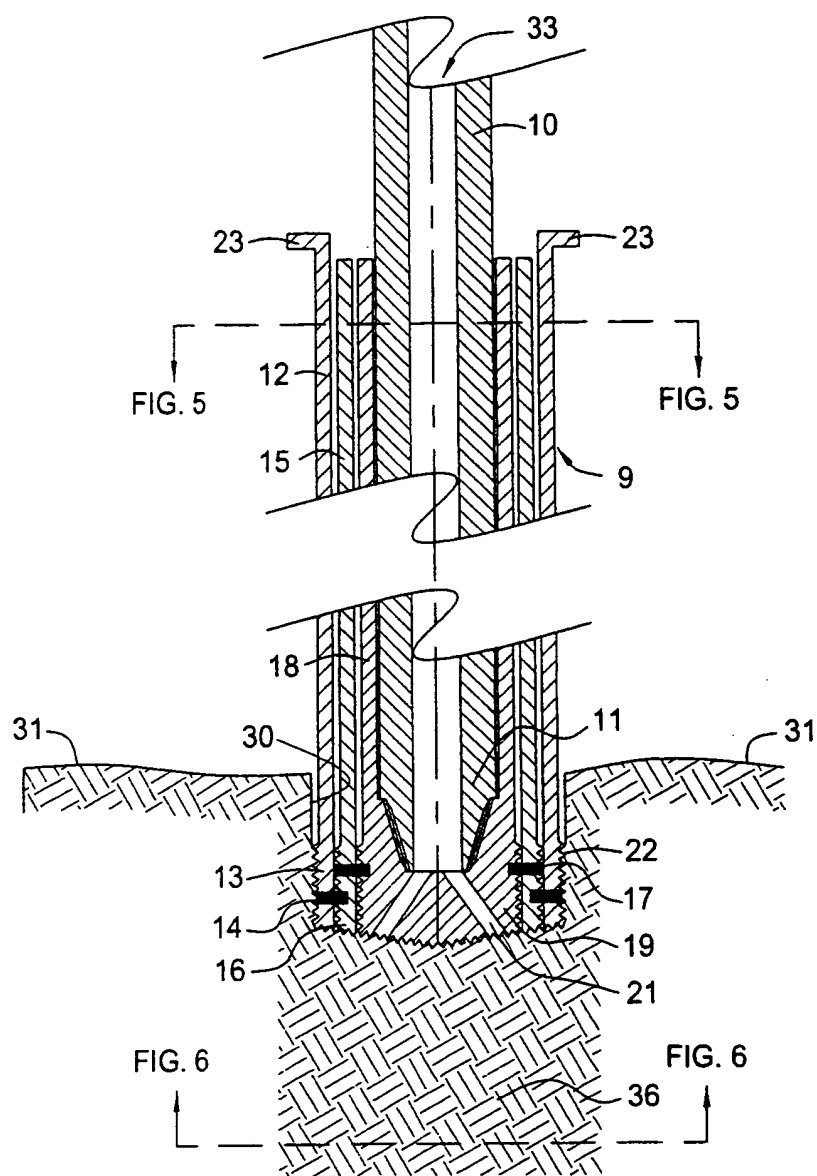


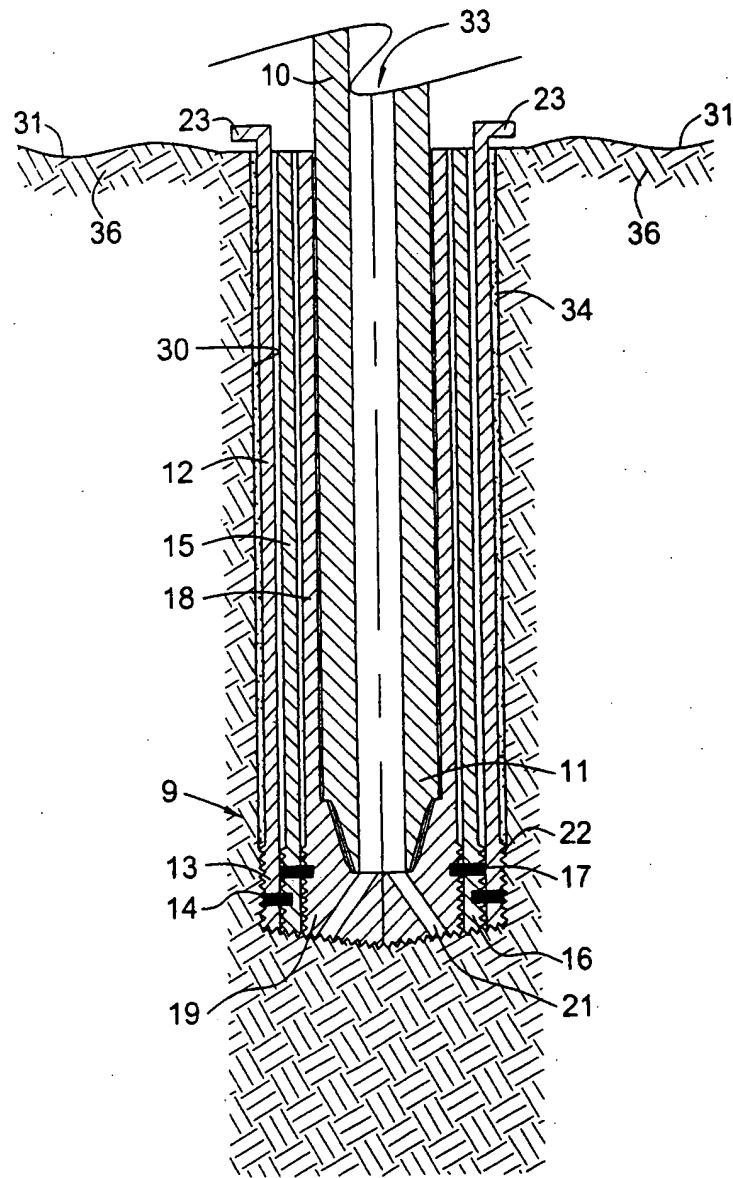
FIG. 1

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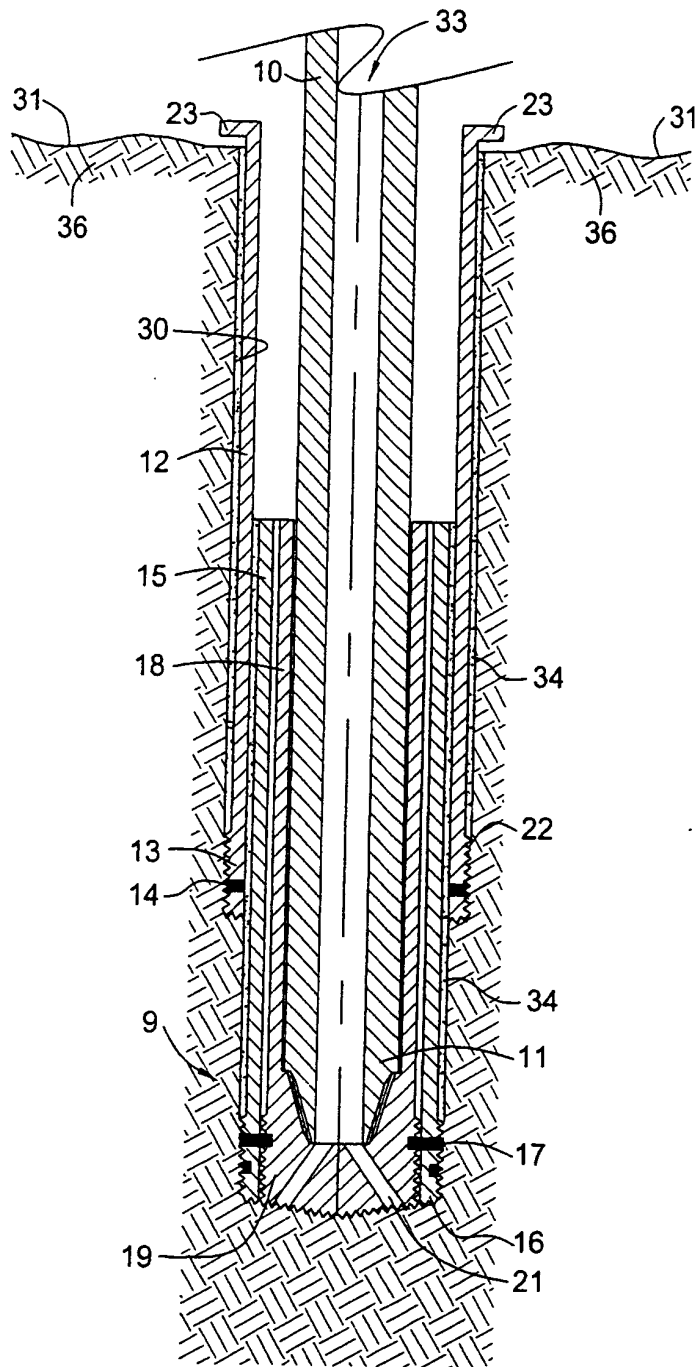
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FIG. 2

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FIG. 3



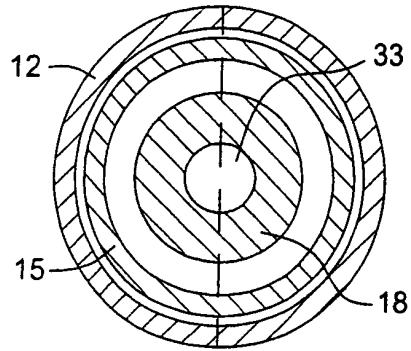


FIG. 5

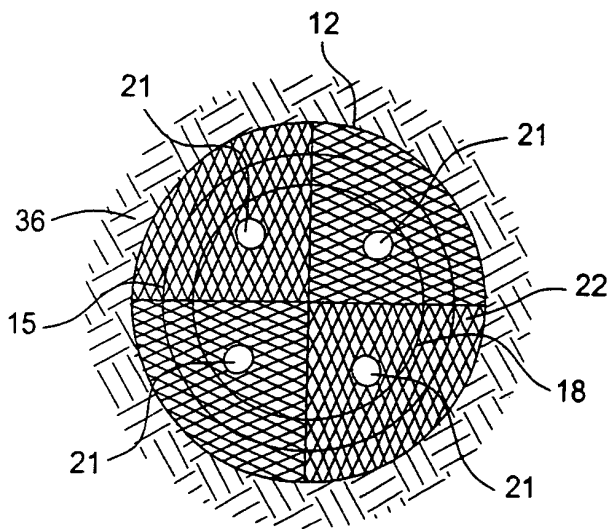
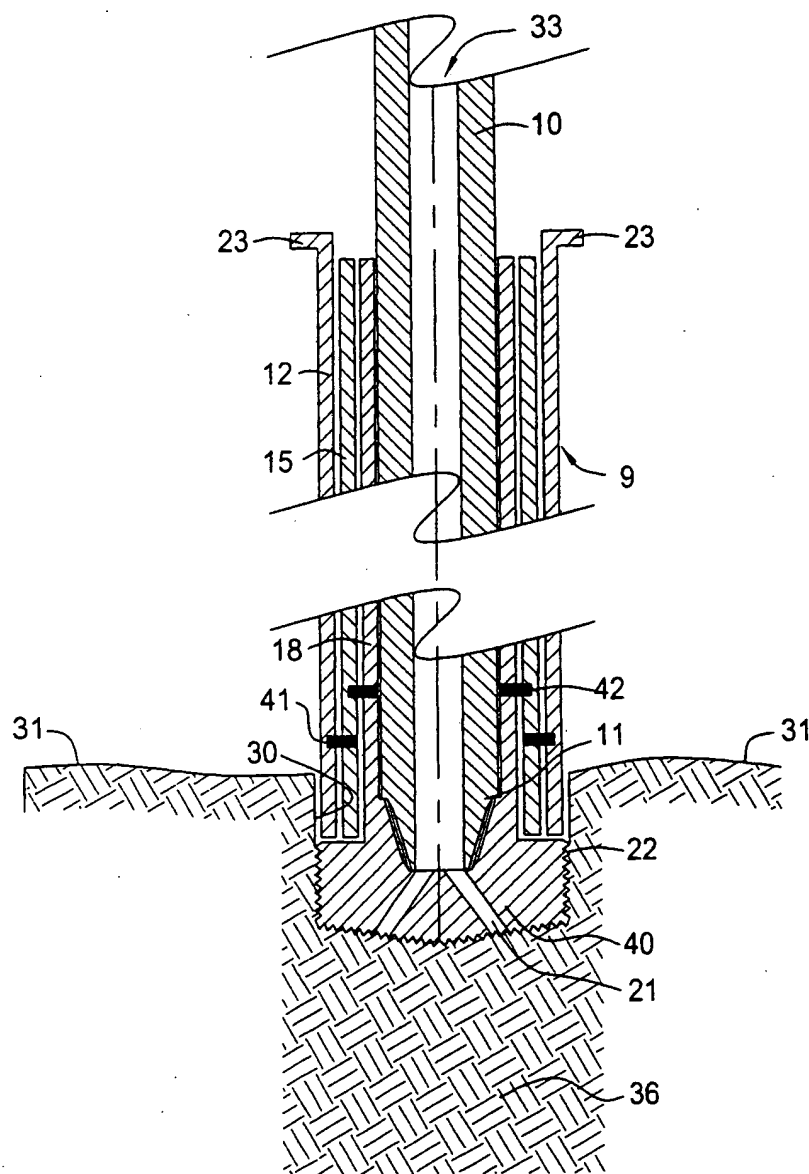


FIG. 6



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DRILLING WITH CONCENTRIC STRINGS OF CASING

The present invention relates to methods and apparatus for forming a wellbore in a well. More specifically, the invention relates to methods and apparatus for forming a wellbore by drilling with casing. More specifically still, the invention relates to drilling a well with drill bit pieces connected to concentric casing strings.

10 In well completion operations, a wellbore is formed to access hydrocarbon-bearing formations by the use of drilling. Drilling is accomplished by utilizing a drill bit that is mounted on the end of a drill support member, commonly known as a drill string. To drill within the wellbore to a predetermined depth, the drill string is often rotated by a top drive or rotary table on a surface platform or rig, or by a downhole motor mounted towards the lower end of the drill string. After drilling to a predetermined depth, the drill string and drill bit are removed and a section of casing is lowered into the wellbore. An annular area is thus formed between the string of casing and the formation. The casing string is temporarily hung from the surface of the well. A cementing operation is then conducted in order to fill the annular area with cement.

25 Using apparatus known in the art, the casing string is cemented into the wellbore by circulating cement into the annular area defined between the outer wall of the casing and the borehole. The combination of cement and casing strengthens the wellbore and facilitates the isolation of certain areas of the formation behind the casing for the production of hydrocarbons.

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In some drilling operations, such as deepwater well completion operations, a conductor pipe is initially placed into the wellbore as a first string of casing. A conductor pipe is the largest diameter pipe that will be placed into the wellbore. The top layer of deepwater wells primarily consists of mud; therefore, the conductor pipe often may merely be pushed downward into the wellbore rather than drilled into the wellbore. To prevent the mud from filling the interior of the conductor pipe, it is necessary to jet the pipe into the ground by forcing pressurized fluid through the inner diameter of the conductor pipe concurrent with pushing the conductor pipe into the wellbore. The fluid and the mud are thus forced to flow upward outside the conductor pipe, so that the conductor pipe remains essentially hollow to receive casing strings of decreasing diameter, as described below.

It is common to employ more than one string of casing in a wellbore. In this respect, the well is drilled to a first designated depth with a drill bit on a drill string. The drill string is removed. A first string of casing or conductor pipe is then run into the wellbore and set in the drilled out portion of the wellbore, and cement is circulated into the annulus behind the casing string. Next, the well is drilled to a second designated depth, and a second string of casing, or liner, is run into the drilled out portion of the wellbore. The second string is set at a depth such that the upper portion of the second string of casing overlaps the lower portion of the first string of casing. The second liner string is then fixed, or "hung" off of the existing casing by the use of slips which utilize slip members and cones to wedgingly fix the new string of

liner in the wellbore. The second casing string is then cemented. This process is typically repeated with additional casing strings until the well has been drilled to total depth. In this manner, wells are typically formed with  
5 two or more strings of casing of an ever-decreasing diameter.

As more casing strings are set in the wellbore, the casing strings become progressively smaller in diameter in  
10 order to fit within the previous casing string. In a drilling operation, the drill bit for drilling to the next predetermined depth must thus become progressively smaller as the diameter of each casing string decreases in order to fit within the previous casing string. Therefore, multiple  
15 drill bits of different sizes are ordinarily necessary for drilling in well completion operations.

Well completion operations are typically accomplished using one of two methods. The first method involves first  
20 running the drill string with the drill bit attached thereto into the wellbore to concentrically drill a hole in which to set the casing string. The drill string must then be removed. Next, the casing string is run into the wellbore on a working string and set within the hole within the  
25 wellbore. These two steps are repeated as desired with progressively smaller drill bits and casing strings until the desired depth is reached. For this method, two run-ins into the wellbore are required per casing string that is set into the wellbore.

30

The second method of performing well completion operations involves drilling with casing, as opposed to the

first method of drilling and then setting the casing. In this method, the casing string is run into the wellbore along with a drill bit for drilling the subsequent, smaller diameter hole located in the interior of the casing string.

5 In a deepwater drilling operation, the conductor pipe includes a drill bit upon run-in of the first casing string which only operates after placement of the conductor pipe by the above described means. The drill bit is operated by concentric rotation of the drill string from the surface of

10 the wellbore. After the conductor pipe is set into the wellbore, the first drill bit is then actuated to drill a subsequent, smaller diameter hole. The first drill bit is then retrieved from the wellbore. The second working string comprises a smaller casing string with a second drill bit in

15 the interior of the casing string. The second drill bit is smaller than the first drill bit so that it fits within the second, smaller casing string. The second casing string is set in the hole that was drilled by the first drill bit on the previous run-in of the first casing string. The second,

20 smaller drill bit then drills a smaller hole for the placement of the third casing upon the next run-in of the casing string. Again the drill bit is retrieved, and subsequent assemblies comprising casing strings with drill bits in the interior of the casing strings are operated

25 until the well is completed to a desired depth. This method requires at least one run-in into the wellbore per casing string that is set into the wellbore.

Both prior art methods of well completion require

30 several run-ins of the casing working string and/or drill string to place subsequent casing strings into the wellbore. Each run-in of the strings to set subsequent casing within

the wellbore is more expensive, as labor costs and equipment costs increase upon each run-in. Accordingly, it is desirable to minimize the number of run-ins of casing working strings and/or drill strings required to set the necessary casing strings within the wellbore to the desired depth.

Furthermore, each run-in of the drill string and/or casing string requires attachment of a different size drill bit to the drill string and/or casing string. Again, this increases labor and equipment costs, as numerous drill bits must be purchased and transported and labor must be utilized to attach the drill bits of decreasing size.

Therefore, a need exists for a drilling system that can set multiple casing strings within the wellbore upon one run-in of the casing working string. Drilling with multiple casing strings temporarily attached concentrically to each other increases the amount of casing that can be set in one run-in of the casing string. Moreover, a need exists for a drill bit assembly which permits drilling with one drill bit for subsequent strings of casing of decreasing diameter. One embodiment of the drilling system of the present invention employs a drilling assembly with one drill bit comprising drill bit pieces releasably connected. Thus, one drill bit is used to drill holes of decreasing diameter within the wellbore for setting casing strings of decreasing diameter. In consequence, operating costs incurred in a well completion operation are correspondingly decreased.

The present invention discloses a drilling system comprising concentric strings of casing having drill bit

pieces connected to the casing, and a method for using the drilling system. In one embodiment, the concentric strings of casing are temporarily connected to one another. In another embodiment, the drill bit pieces are temporarily  
5 connected to one another form a drill bit assembly.

In one aspect of the present invention, the drilling system comprises concentric strings of casing with decreasing diameters located within each other. A conductor  
10 pipe or outermost string of casing comprises the outer casing string of the system. Casing strings of ever-decreasing diameter are located in the hollow interior of the conductor pipe. The drilling system further comprises drill bit pieces connected to the bottom of each casing  
15 string. The drill bit pieces are releasably connected to one another so that they form a drill bit assembly and connect the casing strings to one another.

Located on the outermost casing string on the uppermost  
20 portion of the casing string of the drilling system are hangers connected atop the outermost casing string or conductor pipe which jut radially outward to anchor the drilling assembly to the top of the wellbore. These hangers prevent vertical movement of the outermost casing string and  
25 secure the drilling system upon run-in of the casing string. The drilling assembly is made up of drill bit pieces with cutting structures, where the drill bit pieces are releasably connected to each other. The outermost, first drill bit piece is connected to the conductor pipe and juts  
30 radially outward and downward into the wellbore from the conductor pipe. A smaller, first casing string then contains a similar second drill bit piece which is smaller

than the first drill bit piece. As many drill bits pieces  
and casing strings as are necessary to complete the well may  
be placed on the run-in string. The innermost casing string  
contains a drill bit piece that juts outward and downward  
5 from the casing string and also essentially fills the inner  
diameter of the innermost casing string. The drill bit  
piece disposed at the lower end of the innermost casing  
string contains perforations within it which allow some  
fluid flow downward through the innermost casing string.  
10 The drill bit pieces are releasably connected to each other  
by progressively stronger force as the casing string  
diameters become smaller. In other words, the outer  
connections between drill bit pieces are weaker than the  
inner connections between drill bit pieces. A working  
15 casing string is temporarily connected to the inner diameter  
of the innermost casing string of the drilling system by a  
threadable connection or tong assembly. Fluid and/or mud  
may be pumped into the working casing string during the  
drilling operation. The working casing string permits  
20 rotational force as well as axial force to be applied to the  
drilling system from the surface during the drilling  
operation.

In another aspect of the invention, the drilling system  
25 comprises concentric strings of casing. The concentric  
strings of casing comprise a conductor pipe or outermost  
string of casing and casing strings of ever-decreasing  
diameter within the hollow interior of the conductor pipe.  
The drilling system further comprises at least one drill bit  
30 piece disposed at the lower end of the outermost string of  
casing. The concentric strings of casing are releasably  
connected to one another.

In operation, the drilling system is lowered into the wellbore on the working casing string. In some cases, the drilling system is rotated by applying rotational force to the working casing string from the surface of the well.

- 5 However, as described above, in some deepwater drilling operations, drilling into the well by rotation of the working string is not necessary because the formation is soft enough that the drilling system may merely be pushed downward into the formation to the desired depth when
- 10 setting the conductor pipe. Pressurized fluid is introduced into the working casing string while the drilling system is lowered into the wellbore. When the drilling system is lowered to the desired depth, the downward movement and/or rotational movement stops. A cementing operation is then
- 15 conducted to fill the annular space between the wellbore and the conductor pipe. Next, a downward force is asserted on the working casing string from the surface of the wellbore. The downward force is calculated to break the connection between the drill bit piece of the conductor pipe and the
- 20 drill bit piece of the first casing string. In the alternative embodiment, the force breaks the connection between the conductor pipe and the first string of casing. The conductor pipe remains cemented in the previously drilled hole with its drill bit piece attached to it, while
- 25 the rest of the drilling system falls downward due to the pressure placed on the assembly. In the alternative embodiment, the conductor pipe remains cemented in the previously drilled hole while the entire drill bit piece falls downward with the remainder of the drilling system.
- 30 This process is repeated until enough casing strings are placed in the wellbore to reach the desired depth. The innermost casing string retains the final remaining portion

of the drill bit assembly. In the alternative embodiment, the entire drill bit piece is retained on the innermost casing string.

5       The drilling system of the present invention and the method for using the drilling system allow multiple strings of casing to be set within the wellbore with only one run-in of the casing working string. The drill bit assembly of the present invention permits drilling of multiple holes of  
10 decreasing diameter within the wellbore with only one run-in of the drilling system. Furthermore, the drilling system of the present invention uses one drill bit assembly rather than requiring running in of a drill string or casing working string for each drill bit piece of decreasing  
15 diameter to drill holes in which to place casing strings of decreasing diameter. Therefore, operating and equipment costs in a well completion operation using the drilling system with the drilling assembly are decreased.

20       So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be  
25 noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

30       Figure 1 is a cross-sectional view of one embodiment of the drilling system of the present invention in the run-in configuration.



Figure 2 is a cross-sectional view of the drilling system of Figure 1 disposed in a wellbore after the drilling system is run into a desired depth within the wellbore, with a conductor pipe set within the wellbore.

5

Figure 3 is a cross-sectional view of the drilling system of Figure 1 disposed in a wellbore, with the conductor pipe and a first casing string set within the wellbore.

10

Figure 4 is a cross-sectional view of the drilling system of Figure 1 disposed in a wellbore, with the conductor pipe, the first casing string, and the second casing string set within the wellbore.

15

Figure 5 is a top section view of the concentric casing strings of the present invention, taken along line 5-5 of Figure 1.

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Figure 6 is a top section view of the drilling system of the present invention, taken along line 6-6 of Figure 1.

Figure 7 is a cross-sectional view of an alternative embodiment of the drilling system of the present invention in the run-in configuration.

25

Figure 1 is a cross-sectional view of one embodiment of the drilling system 9 of the present invention in the run-in configuration. The drilling system 9 comprises three concentric strings of casing, including a conductor pipe 12, a first casing string 15, and a second casing string 18. The conductor pipe 12 has a larger diameter than the first

30

casing string 15, and the first casing string 15 has a larger diameter than the second casing string 18. Thus, the second casing string 18 is located within the first casing string 15, which is located within the conductor pipe 12.

5 Although the drilling system 9 depicted in Figure 1 comprises three casing strings, any number of concentric strings of casing may be used in the drilling system 9 of the present invention. Optionally, the drilling system 9 comprises wipers (not shown) disposed in the annular space

10 between the conductor pipe 12 and the first casing string 15 and/or disposed in the annular space between the first casing string 15 and the second casing string 18. The wipers prevent unwanted solids from migrating into the annular spaces between casing strings and debilitating the

15 operation of the drill bit assembly, which is discussed below. Figure 5, which is taken along line 5-5 of Figure 1, shows the upper portion of the concentric strings of casing in a top section view.

20 A first drill bit piece 13 is disposed at the lower end of the conductor pipe 12. In like manner, a second drill bit piece 16 is disposed at the lower end of the first casing string 15, and a third drill bit piece 19 is disposed at the lower end of the second casing string 18. Although

25 the drilling system 9 in Figure 1 shows three casing strings with three drill bit pieces attached thereto, any number of drill bit pieces may be attached to any number of concentric strings of casing in the drilling system 9 of the present invention. The first drill bit piece 13 and second drill

30 bit piece 16 jut outward and downward from the conductor pipe 12 and the first casing string 15, respectively. The drill bit pieces 13, 16, and 19 possess cutting structures

22, which are used to form a path for the casing through a formation 36 during the drilling operation. The cutting structures 22 are disposed on drill bit pieces 13, 16, and 19 on the lower end and the outside portion of each drill bit piece. The innermost casing string, in this case the second casing string 18, comprises a third drill bit piece 19 which juts outward and downward from the second casing string 18 and which also essentially fills the inner diameter of the second casing string 18. Perforations 21 are formed within the third drill bit piece 19 through which fluid may flow during the well completion operation. Figure 6, which is taken along line 6-6 of Figure 1, represents a top section view of the drilling system 9, which shows the perforations 21.

15

Figure 6 represents a top section view of the drilling system 9 of the present invention, which comprises concentric casing strings 12, 15, and 18 with a drill bit assembly attached thereupon. The drill bit assembly is described in reference to Figure 1 as well as Figure 6. The drill bit assembly comprises a first drill bit piece 13 releasably connected to a second drill bit piece 16 by a first connector 14. The assembly further comprises a third drill bit piece 19 releasably connected to the second drill bit piece 16 by a second connector 17. The releasable connections are preferably shearable connections, wherein the first connector 14 holds the first drill bit piece 13 to the second drill bit piece 16 with less force than the second connector 17 holds the second drill bit piece 16 to the third drill bit piece 19. The first drill bit piece 13, the second drill bit piece 16, and the third drill bit piece

19 are located on the lower ends of concentric casing strings 12, 15, and 18, respectively.

5       The first, second and third drill bit pieces, 13, 16, and 19 respectively, possess cutting structures 22 on their outer and bottom surfaces. As described below, after the first drill bit piece 13 is released from the drill bit assembly, the cutting structures 22 on the outer surface of the second drill bit piece 16 are employed to drill through  
10 the formation 36 to a depth to set the first casing string 15. Similarly, after the second drill bit piece 16 is released from the drill bit assembly, the cutting structures 22 on the outer surface of the third drill bit piece 19 are employed to drill through the formation 36 to a depth to set  
15 the second casing string 18.

      As illustrated in Figure 1, the drilling system 9 also comprises hangers 23, which are located on the upper end of the conductor pipe 12. The hangers 23 maintain the drilling  
20 system 9 in place by engaging the surface 31 of the wellbore 30, preventing the drilling system 9 from experiencing further downward movement through the formation 36. Any member suitable for supporting the weight of the drilling system 9 may be used as a hanger 23.

25

      A casing working string 10 is connected to the inner diameter of the second casing string 18. Any type of connection which produces a stronger force than the force produced by the connectors 14 and 17 may be used with the  
30 present invention. Figure 1 shows a type of connection suitable for use with the present invention. A threadable connection 11 is shown between the casing working string 10

and the second casing string 18 which is unthreaded after the drilling operation is completed so that the casing working string 10 may be retrieved. Alternatively, the casing working string 10 may be shearably connected to the second casing string 18 by a tong assembly (not shown). The force produced by the shearable connection of the tong assembly must be greater than the force produced by the connectors 14 and 17. The tong assembly is connected to the lower end of the casing working string 10 and extends radially through the annular space between the casing working string 10 and the inner diameter of the second casing string 18. Upon completion of the drilling operation, the shearable connection is broken by a longitudinal force so that the casing working string 10 may be retrieved from the wellbore 30.

In the drilling system 9, the first drill bit piece 13 is releasably connected to the second drill bit piece 16 by the first connector 14. Similarly, the second drill bit piece 16 is releasably connected to the third drill bit piece 19 by the second connector 17. The releasable connection is preferably a shearable connection. The first connector 14 and the second connector 17 are any connectors capable of temporarily connecting the two drill bit pieces, including weight sheared pins or locking mechanisms. In the embodiment described above, the longitudinal force required to break the connection between the tong assembly and the second casing string 18 is more than the longitudinal force required to break the second connector 17. In the same way, the longitudinal force required to break the second connector 17 is more than the longitudinal force required to break the first connector 14. Accordingly, the connection

between the tong assembly and the second casing string 18 is stronger than the second connector, and the connection produced by the second connector 17 is stronger than the connection produced by the first connector 14.

5

The annular space between casing strings 12 and 15, as well as the annular space between casing strings 15 and 18, may comprise sealing members (not shown) to prevent migration of unwanted fluid and solids into the annular spaces until the designated point in the drilling operation. The sealing members prevent fluid flow into the annular spaces, thus forcing setting fluid to flow into the desired area outside of the casing string being set. The sealing members are released along with their respective connectors 14 and 17 at the designated step in the operation.

Figure 7 shows an alternative embodiment of the drilling system 9 of the present invention in the run-in configuration. In this embodiment, the drilling system 9 is identical to the drilling system of Figure 1 except for the connectors of the drilling system 9 and the drill bit pieces. The numbers used to identify parts of Figure 1 correspond to the numbers used to identify the same parts of Figure 7. In the embodiment of Figure 7, one drill bit piece 40 is disposed at the lower end of the innermost casing string, which is the second casing string 18. Again, any number of concentric casing strings may be employed in the present invention. The drill bit piece 40 comprises perforations 21 which run therethrough and allow fluid flow through the casing working string 10 and into the formation 36. A first connector 41 releasably connects the conductor pipe 12 to the first string of casing 15. Similarly, a

second connector 42 releasably connects the first string of casing 15 to the second string of casing 18. The releasable connection is preferably a shearable connection created by either weight sheared pins or locking mechanisms. The force required to release the second connector 42 is greater than the force required to release the first connector 41. Likewise, the force created by the threadable connection 11 or tong assembly (not shown) is greater than the force required to release the second connector 42.

10

In a further alternative embodiment, the drilling system 9 may employ a torque key system (not shown). A torque key system comprises keys (not shown) located on the inner casing string of the concentric strings of casing which engage slots (not shown) formed in the outer casing string of the concentric strings of casing. The drill bit pieces 13, 16, and 19 of Figure 1 and 40 of Figure 7 comprise a cutting structure (not shown) located above an inverted portion (not shown) of the casing strings 12 and 15. The first torque key system (not shown) comprises keys (not shown) disposed on the first casing string 15 and slots (not shown) disposed on the conductor pipe 12. When the drilling system 9 is used to drill to the desired depth within the formation 36 to set the conductor pipe 12, the keys disposed on the first casing string 15 remain engaged within the slots disposed in the conductor pipe 12, thus restricting rotational movement of the first casing string 15 relative to the conductor pipe 12 so that the first casing string 15 and the conductor pipe 12 translate together. After the drilling system 9 has drilled to the desired depth within the wellbore 30, the key on the first casing string 15 is released from the slot in the conductor

pipe 12, thereby allowing rotational as well as longitudinal movement of the first casing string 15 relative to the conductor pipe 12. Next, the inverted portion of the conductor pipe 12 is milled off by the cutting structure  
5 located above the inverted portion of the conductor pipe 12 so that the drill bit piece 16 may operate to drill to the second designated depth within the wellbore 30 while the second torque key system of the first casing string 15 and the second casing string 18 remains engaged. The second  
10 torque key system operates in the same way as the first torque key system.

In a further embodiment, a spline connection (not shown) may be utilized in place of the torque key system to  
15 restrict rotational movement of the conductor pipe 12 relative to the first casing string 15. In this embodiment, the conductor pipe 12 and the first casing string 15 possess a spline connection (not shown). The spline connection comprises grooves (not shown) formed on an inner surface of  
20 the conductor pipe 12 which mate with splines (not shown) formed on an outer surface of the first casing string 15. The spline, when engaged, allows the first casing string 15 and the conductor pipe 12 to translate rotationally together when the drilling system 9 is drilled to the desired depth,  
25 while at the same time allowing the first casing string 15 and the conductor pipe 12 to move axially relative to one another. When the releasable connection between the first casing string 15 and the conductor pipe 12 is released, the two casing strings 12 and 15 are permitted to rotate  
30 relative to one another. A second spline connection (not shown) may also be disposed on the first casing string 15 and the second casing string 18.



Figures 2, 3, and 4 depict the first embodiment of the drilling system 9 of Figure 1 in operation. Figure 2 is a cross-sectional view of the drilling system 9 of the present invention disposed in a wellbore 30, with the conductor pipe 12 set within the wellbore 30. Figure 3 is a cross-sectional view of the drilling system 9 of the present invention disposed in a wellbore 30, with the conductor pipe 12 and the first casing string 15 set within the wellbore 30. Figure 4 is a cross-sectional view of the drilling system 9 of the present invention disposed in a wellbore 30, with the conductor pipe 12, the first casing string 15, and the second casing string 18 set within the wellbore 30.

In operation, the drilling system 9 is connected to the casing working string 10 running therethrough. As shown in Figures 1 and 7, the casing working string 10 with the drilling system 9 connected is run into a wellbore 30 within the formation 36. While running the casing working string 10 into the wellbore 30, a longitudinal force and a rotational force are applied from the surface 31 upon the casing working string 10. Alternatively, if the formation 36 is sufficiently soft such as in deepwater drilling operations, only a longitudinal force is necessary to run the drilling system 9 into the desired depth within the wellbore 30 to set the conductor pipe 12. Pressurized fluid is introduced into the bore 33 of the casing working string 10 concurrently with running the casing working string 10 into the wellbore 30 so that the fluid and mud that would ordinarily flow upward through the inner diameter of the casing working string 10 are forced to flow upward through the annular space between the conductor pipe 12 and the wellbore 30.

As shown in Figure 2, when the entire length of the conductor pipe 12 is run into the wellbore 30 so that the hangers 23 apply pressure upon the surface 31, the longitudinal force and/or rotational force exerted on the casing working string 10 is halted. A cementing operation is then conducted in order to fill an annular area between the wellbore 30 and the conductor pipe 12 with cement 34. Alternatively, if the friction of the wellbore 30 is sufficient to hold the conductor pipe 12 in place, a cementing operation is not necessary. Figure 2 shows the conductor pipe 12 set within the wellbore 30.

Subsequently, a first longitudinal force is applied to the casing working string 10 from the surface 31. The first longitudinal force breaks the releasable connection between the first drill bit piece 13 and the second drill bit piece 16 that is formed by the first connector 14. Rotational force and longitudinal force are again applied to the casing working string 10 from the surface 31. The remainder of the drilling system 9 exerts rotational and longitudinal force on the formation 36 so that a deeper hole is formed within the wellbore 30 for setting the first casing string 15. This hole is necessarily smaller in diameter than the first hole formed because the drill bit assembly is missing the first drill bit piece 13 and is therefore of decreased diameter. Pressurized fluid is introduced into the bore 33 of the casing working string 10 concurrently with running the drilling system 9 further downward into the wellbore 30 so that the fluid and mud that would ordinarily flow upward through the inner diameter of the casing working string 10 are forced to flow upward in the annular space between the

outer diameter of the first casing string 15 and the inner diameter of the conductor pipe 12.

As shown in Figure 3, when the first casing string 15  
5 is drilled to the desired depth within the wellbore 30, the longitudinal and rotational forces applied on the casing working string 10 are again halted. A cementing operation is then conducted in order to fill an annular area between the conductor pipe 12 and the first casing string 15 with  
10 cement 34. Figure 3 shows the first casing string 15 along with the conductor pipe 12 set within the wellbore 30.

In the next step of the drilling operation, a second longitudinal force is applied to the casing working string  
15 10 from the surface 31. This second longitudinal force is greater than the first longitudinal force, as the second longitudinal force must apply enough pressure to the casing working string 10 to break the releasable connection between the second drill bit piece 16 and the third drill bit piece  
20 19 formed by the second connector 17. Longitudinal and rotational forces are again applied to the remaining portion of the drilling system 9 so that the formation 36 is drilled to the desired depth by the remaining portion of the drill bit assembly. Again, pressurized fluid is run into the bore  
25 33 in the casing working string 10 from the surface 31 concurrent with the rotational and longitudinal force to prevent mud and fluid from traveling upward through the casing working string 10. The mud and fluid introduced into the casing working string 10 exit the system by flowing  
30 upward to the surface 31 through the annular space between the first casing string 15 and the second casing string 18. The hole that is formed by the remaining portion of the

drilling system 9 is even smaller than the previous hole drilled by the drilling system 9 to set the first casing string 15 because the second drill bit piece 16 has released from the drill bit assembly, thus further decreasing the diameter of the drill bit assembly.

As shown in Figure 4, when the drilling system 9 has been drilled into the formation 36 to the desired depth to set the second casing string 18, the longitudinal and rotational forces are again halted. A cementing operation is then conducted in order to fill an annular area between the first casing string 15 and the second casing string 18 with cement 34, thus setting the second casing string 18. The completed operation is shown in Figure 4.

At the end of the drilling operation, the remainder of the drilling system 9, which comprises the third drill bit piece 19 and the second casing string 18, permanently resides in the wellbore 30. The threadable connection 11 is disconnected from the inner diameter of the second casing string 18, and the casing working string 10 and the threadable connection 11 are removed from the wellbore 30.

The second embodiment depicted in Figure 7 works in much the same way as the first embodiment of the present invention, with minor differences. Instead of using longitudinal force to release the connectors 14 and 17 between the drill bit pieces, the force is used to release the connectors 41 and 42 between the concentric strings of casing 12, 15, and 18. A first longitudinal force is used to break the first connector 41 between the conductor pipe 12 and the first casing string 15. A second, greater

longitudinal force is used to break the second connector 42 between the first string of casing 15 and the second string of casing 18. Finally, the threadable connection 11 is unthreaded after the drilling operation is completed so that the casing working string 10 may be retrieved. Alternatively, a third, even greater longitudinal force may be used to break the shearable connection between the tong assembly (not shown) and the second casing string 18. Because drill bit pieces are not disposed at the lower end of casing strings 12 and 15, drill bit pieces are not left within the wellbore during the course of the operation, but remain attached to the drilling system 9 until the final stage. The drill bit piece 40 is carried with the second casing string 18 during the entire operation and remains attached to the second string of casing 18 within the wellbore upon completion of the drilling operation. In any of the embodiments described above, the connectors 14 and 17 or the connectors 41 and 42 may alternatively comprise an assembly which is removable from the surface using wireline, tubing, or drill pipe at the end of drilling operation. Furthermore, the connectors 14 and 17 and the connectors 41 and 42 may comprise an assembly that may be de-activated from the surface 31 of the wellbore 30 by pressure within the casing strings 12, 15, and 18.

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An alternate method (not shown) of setting the casing strings 12, 15, and 18 within the wellbore 30 involves using any of the above methods to drill the casing strings 12, 15, and 18 to the desired depth within the wellbore 30. However, instead of conducting a cementing operation at each stage in the operation after each casing string has reached its desired depth within the wellbore 30, each of the casing

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strings 12, 15, and 18 are lowered to the final depth of the entire drilling system 9 (as shown in Figure 4). Figure 4 is used for illustrative purposes in the description below, although other embodiments of the drilling system 9 described above may be used to accomplish this alternative method. The drilling system 9 is lowered to the desired depth for setting the conductor pipe 12 by rotational and longitudinal forces. Then, the rotational force is halted and the longitudinal force is utilized to release the first connector 14. The conductor pipe 12 is fixed longitudinally and rotationally within the wellbore 30 by the portion 45 of the formation 36 which extends beyond the remaining portion of the drilling system 9. The remaining portion of the drilling system 9 which comprises the first string of casing 15 and the second casing string 18 is drilled to the second desired depth within the wellbore 30, and the process is repeated until the entire drilling system 9 has telescoped to the desired depth within the wellbore 30. Then, a cementing operation is conducted to set all of the casing strings 12, 15, and 18 within the wellbore 30 at the same time.

CLAIMS

1. A drilling system for setting concentric casing strings within a wellbore, comprising:
  - 5 at least two strings of casing, wherein the outer diameter of the inner string of casing is smaller than the inner diameter of the outer string of casing;  
a drill bit piece disposed at the lower end of at least one of the at least two strings of casing; and
  - 10 a connector which releasably connects adjacent casing strings.
2. The drilling system of claim 1, wherein the at least two strings of casing comprise an innermost string of casing  
15 and wherein the drill bit piece is disposed at the lower end of the innermost string of casing.
3. The drilling system of claim 1, wherein the drilling system comprises at least three strings of casing and  
20 connectors which releasably connect adjacent casing strings, and wherein a drill bit piece is disposed at the lower end of at least one of the at least three strings of casing.
4. The drilling system of claim 3, wherein the at least  
25 three strings of casing comprise an innermost string of casing and wherein the drill bit piece is disposed at the lower end of the innermost string of casing.
5. The drilling system of claim 3 or claim 4, wherein the  
30 force required to release the releasable connection increases as the diameter of the strings of casing decreases.

6. The drilling system of any of claims 3 to 5, wherein the connectors comprise an assembly removable from the wellbore.

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7. The drilling system of any of claims 3 to 6, wherein the connectors comprises an assembly that can be deactivated from the surface of the wellbore by establishing sufficient pressure within the casing strings.

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8. The drilling system of any preceding claim, wherein the drill bit piece comprises perforations for fluid flow therethrough.

15 9. The drilling system of any preceding claim, further comprising hangers disposed on the upper end of an outermost string of casing of the at least two strings of casing, wherein the hangers support the weight of the drilling system from a surface of the wellbore.

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10. The drilling system of any preceding claim, further comprising a casing working string releasably connected to an inner diameter of an innermost string of casing of the at least two strings of casing.

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11. The drilling system of any preceding claim, wherein the or each connector comprise weight sheared pins or locking mechanisms.

30 12. The drilling system of any preceding claim, further comprising a sealing member disposed between the at least two strings of casing.



13. The drilling system of any preceding claim, further comprising a wiper disposed between the at least two strings of casing.

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14. The drilling system of any preceding claim, further comprising a torque key system, wherein the torque key system prevents rotational translation of the at least two strings of casing relative to one another.

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15. The drilling system of any of claims 1 to 13, further comprising a spline assembly, wherein the spline assembly prevents rotational translation of the at least two strings of casing relative to one another.

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16. A method for setting at least two strings of casing within a wellbore, the at least two strings of casing comprising a second string of casing disposed within a first string of casing, comprising:

20       running a casing working string into the wellbore, the casing working string comprising:

the at least two strings of casing releasably connected to one another; and

a drill bit piece disposed at the lower end of at least one  
25 of the at least two strings of casing;

setting the first string of casing within the wellbore;  
releasing the releasable connection between the first string of casing and the second string of casing;

running the casing working string into the wellbore to  
30 a second depth while applying rotational force to the drill bit piece; and

setting the second string of casing within the wellbore.

17. The method of claim 16, further comprising  
5 disconnecting the casing working string from the strings of casing and retrieving the casing working string from the wellbore.

18. The method of claim 16 or 17, further comprising  
10 introducing pressurized fluid into the casing working string while running the casing working string into the wellbore to a first depth and while running the casing working string into the wellbore to the second depth.

15 19. The method of any of claims 16 to 18, wherein setting the strings of casing comprises introducing setting fluid into an annular area between the wellbore and the string of casing which is being set.

20 20. The method of claim 19, wherein the setting fluid is introduced into the annular area only after the casing working string is run into the wellbore to the second depth.

21. The method of any of claims 16 to 20, wherein the  
25 rotational force is discontinued before setting the strings of casing within the wellbore.

22. The method of any of claims 16 to 21, wherein the  
30 rotational force is supplied by a top drive motor or a rotary table at a surface of the wellbore.

23. A method for setting at least three strings of casing within a wellbore, the at least three strings of casing comprising a second string of casing disposed within a first string of casing and a third string of casing disposed within the second string of casing, comprising:
- 5 running a casing working string into the wellbore while applying rotational force to the casing working string, the casing working string comprising:
- the at least three strings of casing; and
- 10 drill bit pieces disposed at the lower end of each string of casing, the drill bit pieces releasably connected to each other;
- setting the first string of casing within the wellbore;
- applying a first force to break the releasable
- 15 connection between the first string of casing and the second string of casing;
- running the casing working string into the wellbore to a second depth while applying rotational force to the casing working string;
- 20 setting the second string of casing within the wellbore;
- applying a second force to break the releasable connection between the second string of casing and the third string of casing;
- 25 running the casing working string into the wellbore to a third depth while applying rotational force to the casing working string; and
- setting the third string of casing within the wellbore.
- 30 24. The method of claim 23, further comprising disconnecting the casing working string from the at least

three strings of casing and retrieving the casing working string from the wellbore.

25. The method of claim 23 or 24, further comprising  
5 introducing pressurized fluid into the casing working string while running the casing working string into the wellbore to a first depth, while running the casing working string to a second depth, and while running the casing working string into the wellbore to a third depth.

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26. The method of any of claims 23 to 25, wherein setting the at least three strings of casing comprises introducing setting fluid into an annular area between the wellbore and the string of casing which is being set.

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27. The method of claim 26, wherein the setting fluid is introduced into the annular area only after the casing working string is run into the wellbore to the third depth.

20 28. The method of any of claims 23 to 27, wherein the rotational force is discontinued before setting the at least three strings of casing within the wellbore.

25 29. The method of any of claims 23 to 28, wherein the rotational force is supplied by a top drive motor or a rotary table at a surface of the wellbore.

30 30. The method of any of claims 23 to 29, wherein the second force is greater than the first force.

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31. A drill bit assembly for setting concentric casing strings within a wellbore, comprising:

drill bit pieces which are releasably connected to one another, wherein the force produced by the releasable connection between the outermost drill bit pieces is weaker than the force produced by the releasable connection between  
5 the innermost drill bit pieces.

32. The drill bit assembly of claim 31, wherein the drill bit pieces comprise cutting structures disposed on lower and outer ends of the drill bit pieces.

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33. The method of claim 31 or 32, wherein the releasable connection is a shearable connection.

34. The drill bit assembly of claim 33, wherein the  
15 shearable connection comprises weight sheared pins or locking mechanisms.

35. The drill bit assembly of any of claims 31 to 34, further comprising perforations located within the innermost  
20 drill bit piece.

36. A method of drilling with casing comprising:  
forming a first section of wellbore with a first casing string, the first casing string having a bore forming member  
25 at a lower end thereof; and

forming a second section of wellbore with a second casing string, the second casing string selectively extending telescopically from the lower end of the first casing string.

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Application No: GB 0329889.0  
Claims searched: 1 & 16

Examiner: Bob Crowshaw  
Date of search: 8 March 2004

## Patents Act 1977 : Search Report under Section 17

### Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1 & 16 at least	US4100981 (CHAFFIN) Whole document particularly relevant, but see especially column 2 lines 25-36, column 7 lines 36 to column 8 line 39, and claims 1 & 12.

### Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art
Y	Document indicating lack of inventive step if combined with one or more other documents of same category	P	Document published on or after the declared priority date but before the filing date of this invention
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application

### Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC<sup>w</sup>

E1F

Worldwide search of patent documents classified in the following areas of the IPC<sup>7</sup>.

E21B

The following online and other databases have been used in the preparation of this search report:

Online databases: EPODOC, JAPIO, WPI